

EVALUATION KIT  
AVAILABLE**MAXIM**

## 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

MAX9715

### General Description

The MAX9715 high-efficiency, stereo, Class D audio power amplifier provides up to 2.8W per channel into a 4Ω speaker with a 5V supply. Maxim's second-generation Class D technology features robust output protection, high efficiency, and high power-supply rejection (PSRR) while eliminating the need for output filters. Selectable gain settings, +10.5dB or +9.0dB, adjust the amplifier gain to suit the audio input level and speaker load.

The MAX9715 features high PSRR (71dB at 1kHz), allowing for operation from noisy supplies without additional regulation. Comprehensive click-and-pop suppression eliminates audible clicks and pops at startup and shutdown. The MAX9715 operates from a single 5V supply and consumes only 12mA of supply current. Integrated shutdown control reduces supply current to less than 100nA.

The MAX9715 is fully specified over the extended -40°C to +85°C temperature range and is available in thermally enhanced 16-pin thin QFN-EP and 16-pin TSSOP packages.

### Features

- ◆ 5V Single-Supply Operation
- ◆ Patented Spread-Spectrum Modulator Reduces EMI
- ◆ 2.8W, Class D, Stereo Speaker Amplifier (4Ω)
- ◆ Filterless Class D Requires No LC Output Filter
- ◆ High PSRR (71dB at 1kHz)
- ◆ 86% Efficiency ( $R_L = 8\Omega$ ,  $P_{OUT} = 1W$ )
- ◆ Low-Power Shutdown Mode
- ◆ Integrated Click-and-Pop Suppression
- ◆ Low Total Harmonic Distortion: 0.06% at 1kHz
- ◆ Short-Circuit and Thermal Protection
- ◆ Internal Gain, +9.0dB or +10.5dB
- ◆ Available in Space-Saving Packages
  - 16-Pin Thin QFN-EP (5mm x 5mm x 0.8mm)
  - 16-Pin TSSOP

### Applications

High-End Notebook Audio  
LCD Projectors  
Portable Audio  
Multimedia Docking Stations

Typical Operating Circuit/Functional Diagram appears at end of data sheet.

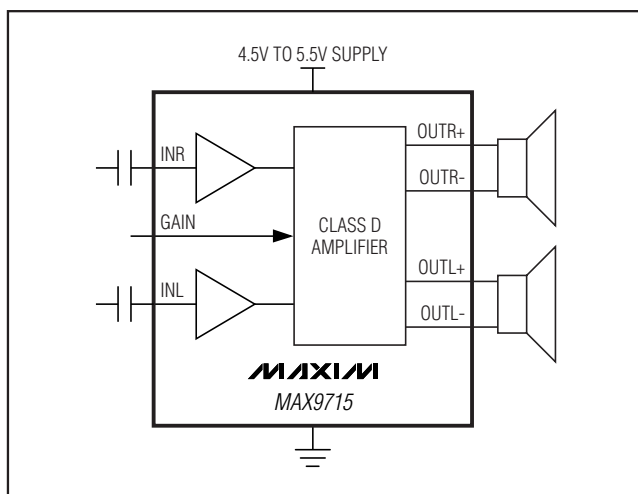
### Ordering Information

| PART        | TEMP RANGE     | PIN-PACKAGE |
|-------------|----------------|-------------|
| MAX9715ETE+ | -40°C to +85°C | 16 TQFN-EP* |
| MAX9715EUE+ | -40°C to +85°C | 16 TSSOP    |

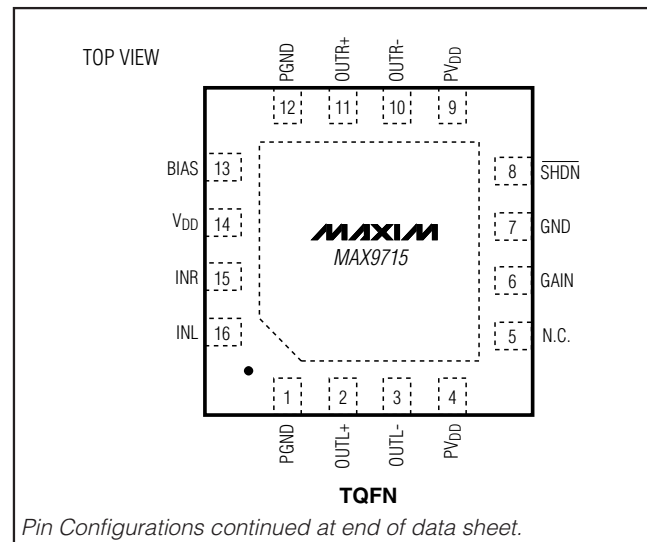
+Denotes lead-free package.

\*EP = Exposed paddle.

### Block Diagram



### Pin Configurations

**MAXIM**

Maxim Integrated Products 1

For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at [www.maxim-ic.com](http://www.maxim-ic.com).

[www.DataSheet4U.com](http://www.DataSheet4U.com)

# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

## ABSOLUTE MAXIMUM RATINGS

V<sub>DD</sub>, PV<sub>DD</sub>, to GND .....+6V  
 GND to PGND .....-0.3V to +0.3V  
 Any Other Pin to PGND ..... -0.3V to (V<sub>DD</sub> + 0.3V)  
 Duration of OUT\_ Short Circuit to PGND or PV<sub>DD</sub>.....Continuous  
 Duration of OUT\_+ Short Circuit between OUT\_-.....Continuous  
 Continuous Current Into/Out of (PV<sub>DD</sub>, OUT\_-, PGND).....1.7A  
 Continuous Input Current (All Other Pins) ..... ±20mA

Continuous Power Dissipation (T<sub>A</sub> = +70°C)  
 16-Pin TQFN-EP (derate 20.8mW/°C above +70°C)..1666mW  
 16-Pin TSSOP (derate 9.4mW/°C above +70°C) .....754.7mW  
 Operating Temperature Range .....-40°C to +85°C  
 Storage Temperature Range .....-65°C to +150°C  
 Junction Temperature .....+150°C  
 Lead Temperature (soldering, 10s) .....+300°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

(V<sub>DD</sub> = PV<sub>DD</sub> = 5.0V, GND = PGND = 0V, V<sub>SHDN</sub> = V<sub>DD</sub>, C<sub>BIAS</sub> = 1μF, speaker impedance = 8Ω in series with 68μH connected between OUT\_+ and OUT\_-, GAIN = +10.5dB, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted. Typical values are at T<sub>A</sub> = +25°C.) (Notes 1, 2)

| PARAMETER                               | SYMBOL             | CONDITIONS  |  | MIN  | TYP  | MAX  | UNITS |
|---|--------------------|---|--|------|------|------|-------|
| <b>GENERAL</b>                          |                    |   |  |      |      |      |       |
| Supply Voltage Range                    | V <sub>DD</sub>    | Inferred from PSRR test                               |  | 4.5  |      | 5.5  | V     |
| Quiescent Current                       | I <sub>DD</sub>    | No load   |  |      | 12.8 | 16   | mA    |
| Shutdown Supply Current                 | I <sub>SHDN</sub>  | V <sub>SHDN</sub> = 0V                                |  |      | 0.1  | 2    | μA    |
| Input Resistance                        | R <sub>IN</sub>    |   |  | 6.5  | 10   | 13.5 | kΩ    |
| Turn-On Time                            | t <sub>ON</sub>    |   |  |      | 25   |      | ms    |
| BIAS Voltage                            | V <sub>BIAS</sub>  |   |  |      | 1.8  |      | V     |
| <b>CLASS D SPEAKER AMPLIFIERS</b>       |                    |   |  |      |      |      |       |
| Output Offset Voltage                   | V <sub>OS</sub>    | T <sub>A</sub> = +25°C                                |  |      | 12.6 | 45   | mV    |
|   |                    | T <sub>A</sub> = T <sub>MIN</sub> to T <sub>MAX</sub> |  |      |      | 70   |       |
| Maximum Speaker Amplifier Gain (Note 3) | A <sub>v</sub>     | GAIN = 0  |  |      | 10.5 |      | dB    |
|   |                    | GAIN = 1  |  |      | 9.0  |      |       |
| Power-Supply Rejection Ratio            | PSRR               | V <sub>IN-</sub> = 0V                                 | PV <sub>DD</sub> or V <sub>DD</sub> = 4.5V to 5.5V | 52.4 | 75   |      | dB    |
|   |                    |   | f = 1kHz, 100mV <sub>p-p</sub>                     |      | 71   |      |       |
|   |                    |   | f = 20kHz, 100mV <sub>p-p</sub>                    |      | 60   |      |       |
| Output Power                            | P <sub>OUT</sub>   | THD+N = 1%  | R <sub>L</sub> = 8Ω                                |      | 1.4  |      | W     |
|   |                    |   | R <sub>L</sub> = 4Ω                                |      | 2.3  |      |       |
|   |                    | THD+N = 10%   | R <sub>L</sub> = 8Ω                                |      | 1.7  |      |       |
|   |                    |   | R <sub>L</sub> = 4Ω                                |      | 2.8  |      |       |
| Total Harmonic Distortion Plus Noise    | THD+N              | f = 1kHz  | R <sub>L</sub> = 8Ω, P <sub>OUT</sub> = 1.2W       |      | 0.06 |      | %     |
|   |                    |   | R <sub>L</sub> = 4Ω, P <sub>OUT</sub> = 2W         |      | 0.07 |      |       |
| Signal-to-Noise Ratio                   | SNR                | P <sub>OUT</sub> = 1W, BW = 22kHz to 22kHz            |  |      | 89   |      | dB    |
|   |                    | P <sub>OUT</sub> = 1W, A-weighted                     |  |      | 93   |      |       |
| Maximum Capacitive Load                 | C <sub>L_MAX</sub> |   |  |      | 200  |      | pF    |
| Switching Frequency                     | f <sub>sw</sub>    | Average frequency in spread-spectrum operation        |  | 1.00 | 1.22 | 1.40 | MHz   |

# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

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## ELECTRICAL CHARACTERISTICS (continued)

( $V_{DD} = PV_{DD} = 5.0V$ ,  $GND = PGND = 0V$ ,  $V_{SHDN} = V_{DD}$ ,  $C_{BIAS} = 1\mu F$ , speaker impedance =  $8\Omega$  in series with  $68\mu H$  connected between  $OUT_{+}$  and  $OUT_{-}$ ,  $GAIN = +10.5dB$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ , unless otherwise noted. Typical values are at  $T_A = +25^{\circ}C$ .) (Notes 1, 2)

| PARAMETER                             | SYMBOL     | CONDITIONS  | MIN             | TYP       | MAX       | UNITS   |
|---------------------------------------|------------|---|-----------------|-----------|-----------|---------|
| Spread-Spectrum Modulation            |            |   |                 | $\pm 120$ |           | kHz     |
| Crosstalk                             |            | Channel-to-channel, $f = 10kHz$ , $P_{OUT} = 1W$ , left to right or right to left |                 | 72        |           | dB      |
| Click-and-Pop Level                   | $K_{CP}$   | Peak voltage, A-weighted, 32 samples per second (Note 4)                          | Into shutdown   |           | -64       | dBV     |
|                                       |            |   | Out of shutdown |           | -46       |         |
| Efficiency                            | $\eta$     | $R_L = 8\Omega$ in series with $68\mu H$ , $P_{OUT} = 1W$ per channel, $f = 1kHz$ |                 | 86        |           | %       |
| <b>DIGITAL INPUTS (GAIN and SHDN)</b> |            |   |                 |           |           |         |
| Input High Voltage                    | $V_{IH}$   |   | 2.0             |           |           | V       |
| Input Low Voltage                     | $V_{IL}$   |   |                 |           | 0.8       | V       |
| Input Leakage Current                 | $I_{LEAK}$ | SHDN  |                 |           | $\pm 1$   | $\mu A$ |
|                                       |            | GAIN  |                 |           | $\pm 1.5$ |         |

**Note 1:** All devices are 100% production tested at  $T_A = +25^{\circ}C$ . All temperature limits are guaranteed by design.

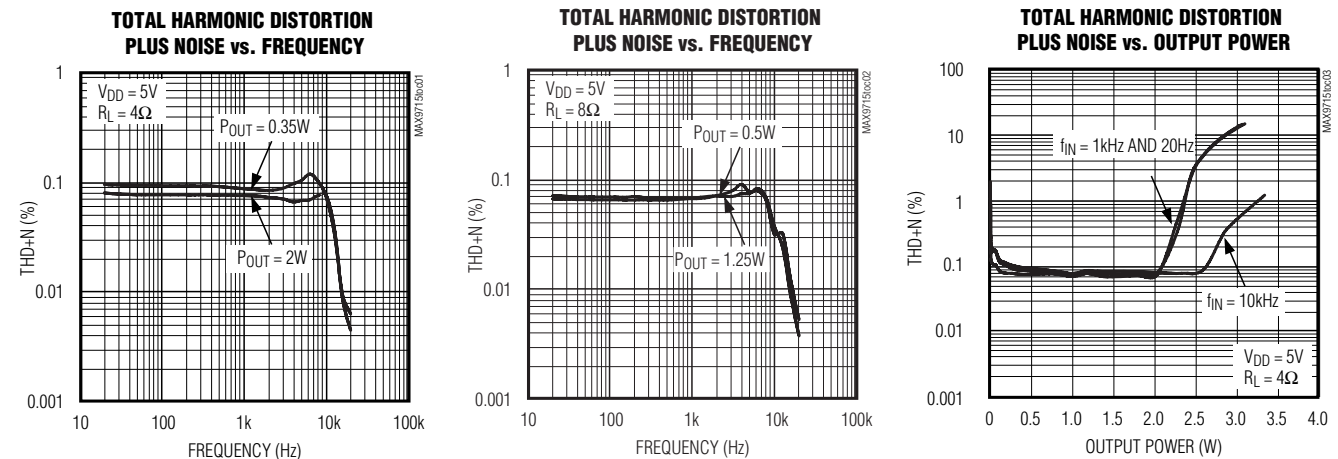
**Note 2:** Speaker amplifier gain is defined as  $A_V = (V_{OUT_{+}} - V_{OUT_{-}}) / V_{IN}$ .

**Note 3:** Click-and-pop level testing performed with an  $8\Omega$  resistive load in series with  $68\mu H$  inductive load connected across the Class D BTL outputs. Mode transitions are controlled by the SHDN pin. Inputs AC-coupled to GND.

**Note 4:** Testing performed with a resistive load in series with an inductor to simulate an actual speaker load. For  $R_L = 4\Omega$ ,  $L = 33\mu H$ . For  $R_L = 8\Omega$ ,  $L = 68\mu H$ .

## Typical Operating Characteristics

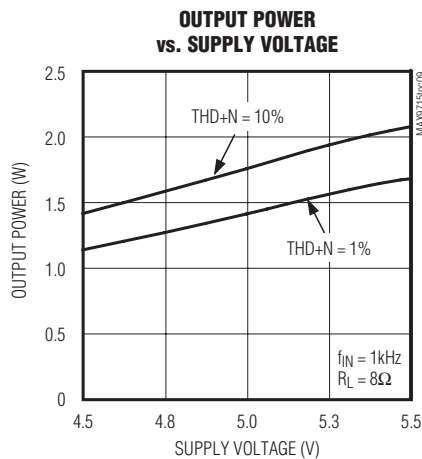
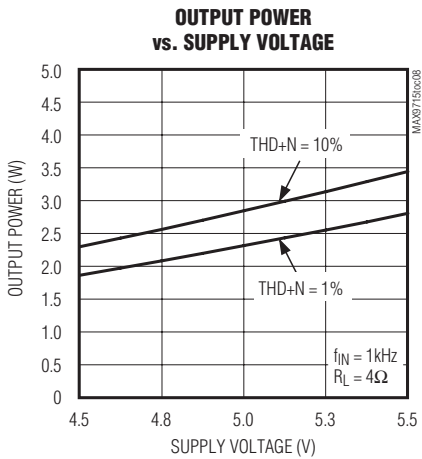
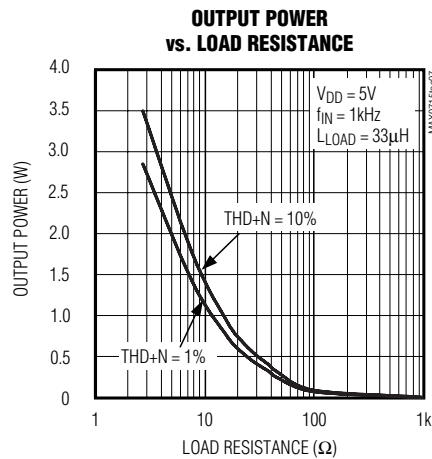
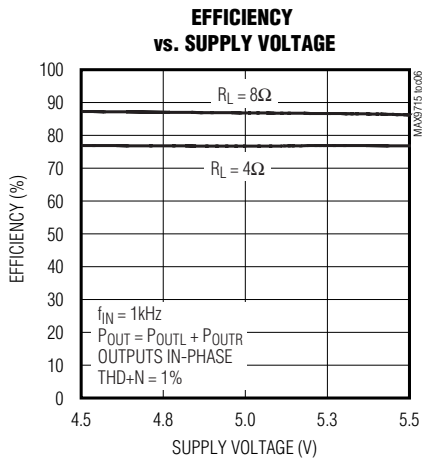
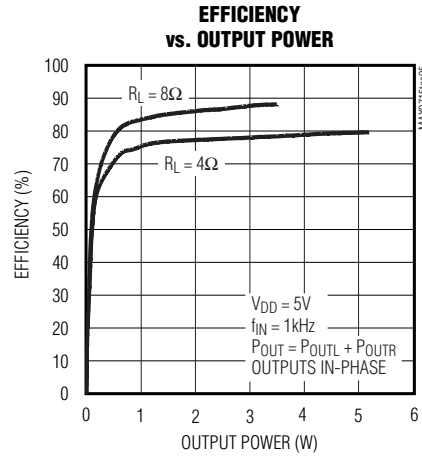
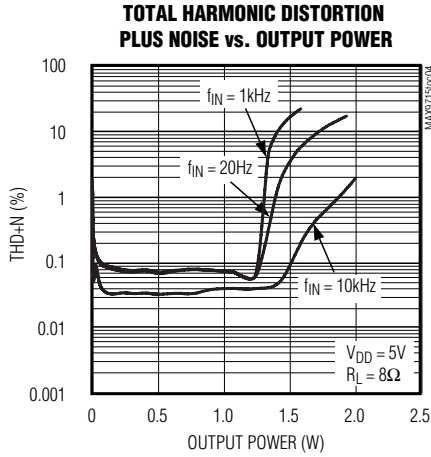
( $V_{DD} = 5.0V$ ,  $C_{VDD} = 3 \times 0.1\mu F$ ,  $C_{BIAS} = 1\mu F$ ,  $C_{INL} = C_{INR} = 1\mu F$ ,  $A_V = +10.5dB$ ,  $T_A = +25^{\circ}C$ , unless otherwise noted.) (See the Typical Operating Circuit/Functional Diagram)



# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

## Typical Operating Characteristics (continued)

( $V_{DD} = 5.0V$ ,  $C_{VDD} = 3 \times 0.1\mu F$ ,  $C_{BIAS} = 1\mu F$ ,  $C_{INL} = C_{INR} = 1\mu F$ ,  $A_V = +10.5dB$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (See the Typical Operating Circuit/Functional Diagram)



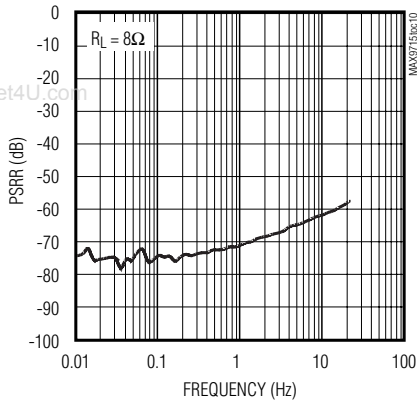
# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

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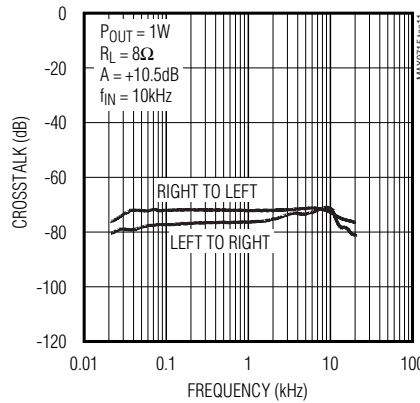
## Typical Operating Characteristics (continued)

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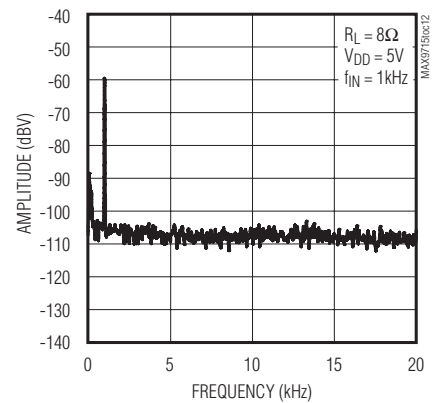
**POWER-SUPPLY REJECTION RATIO vs. FREQUENCY**



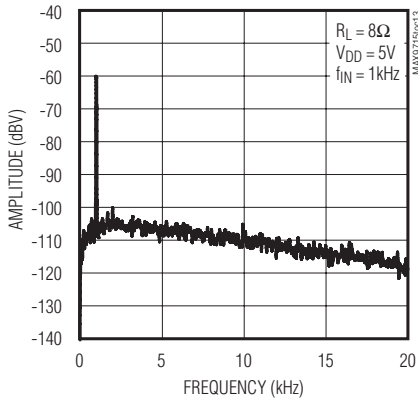
**CROSSTALK vs. FREQUENCY**



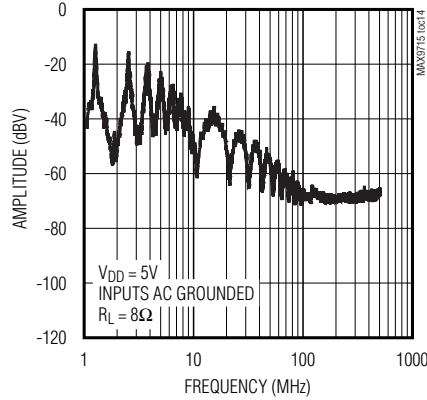
**OUTPUT SPECTRUM vs. FREQUENCY**



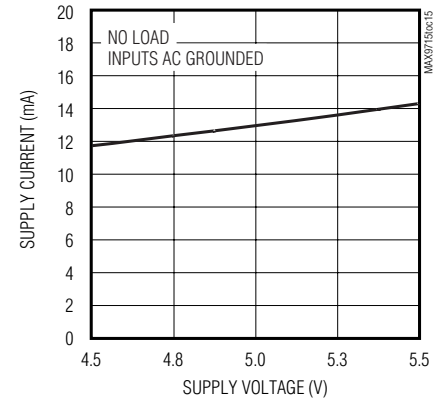
**OUTPUT SPECTRUM vs. FREQUENCY (A-WEIGHTED)**



**WIDEBAND SPECTRUM**



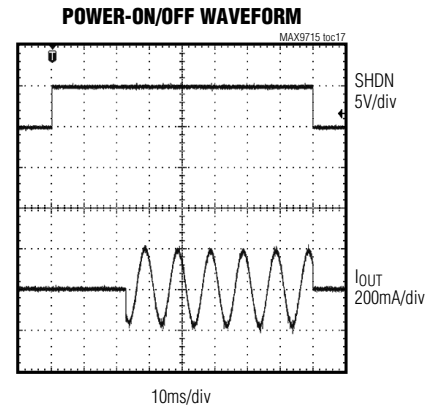
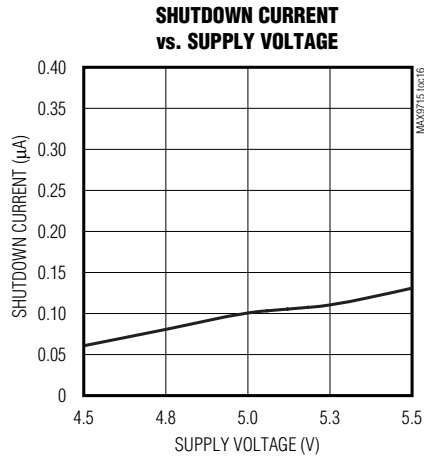
**SUPPLY CURRENT vs. SUPPLY VOLTAGE**



## 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

### Typical Operating Characteristics (continued)

( $V_{DD} = 5.0V$ ,  $C_{VDD} = 3 \times 0.1\mu F$ ,  $C_{BIAS} = 1\mu F$ ,  $C_{INL} = C_{INR} = 1\mu F$ ,  $A_V = +10.5dB$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (See the Typical Operating Circuit/Functional Diagram)



### Pin Description

| PIN   |       | NAME              | FUNCTION   |
|-------|-------|-------------------|--|
| TQFN  | TSSOP |                   |  |
| 1, 12 | 4, 13 | PGND              | Power Ground   |
| 2     | 5     | OUTL+             | Left-Channel Positive Speaker Output   |
| 3     | 6     | OUTL-             | Left-Channel Negative Speaker Output   |
| 4, 9  | 7, 10 | PVDD              | Positive Speaker Power-Supply Input. Power-supply input for speaker amplifier output stages. Connect to $V_{DD}$ and bypass with $0.1\mu F$ to PGND. |
| 5     | —     | N.C.              | No connection. Not internally connected.   |
| 6     | 8     | GAIN              | Gain Select. Sets the internal amplifier gain. See the <i>Gain Selection</i> section.  |
| 7     | 1, 14 | GND               | Ground   |
| 8     | 9     | $\overline{SHDN}$ | Shutdown Control. Drive $\overline{SHDN}$ low to shut down the MAX9715.  |
| 10    | 11    | OUTR-             | Right-Channel Negative Speaker Output  |
| 11    | 12    | OUTR+             | Right-Channel Positive Speaker Output  |
| 13    | 15    | BIAS              | Bias Voltage Output. $V_{BIAS} = 1.8V$ , bypass BIAS to GND with a $1\mu F$ ceramic capacitor.   |
| 14    | 16    | $V_{DD}$          | Positive Power-Supply Input. Bypass to GND with a $0.1\mu F$ ceramic capacitor.  |
| 15    | 2     | INR               | Right-Channel Input  |
| 16    | 3     | INL               | Left-Channel Input   |
| EP    | —     | EP                | Exposed Paddle. Connect EP to an electrically isolated copper pad or GND.  |

# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

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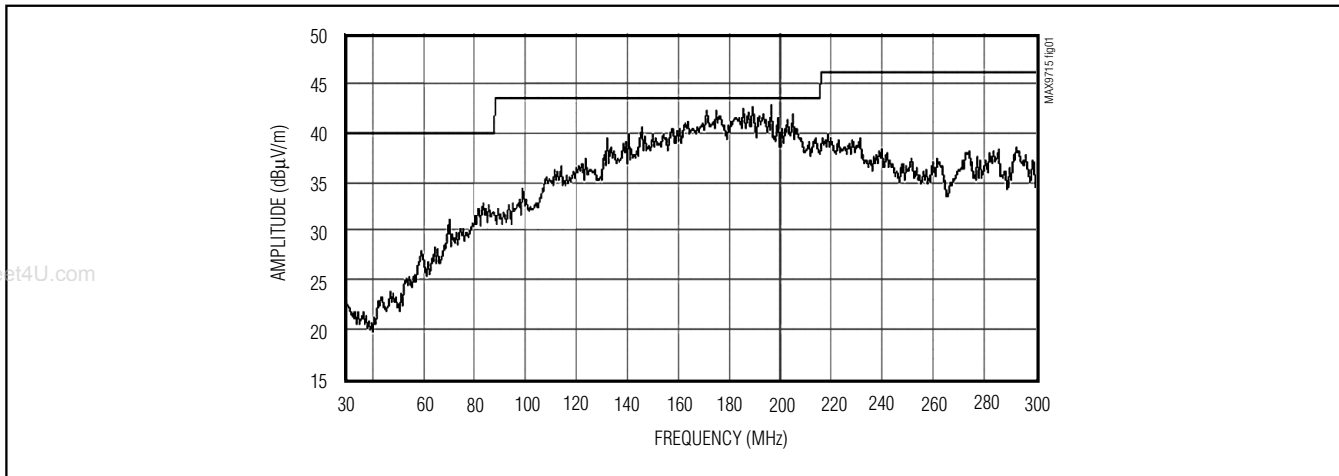


Figure 1. MAX9715 Radiated Emissions with 75mm of Speaker Cable

## Detailed Description

The MAX9715 2.8W, Class D speaker amplifier with gain control offers Class AB performance with Class D efficiency while occupying minimal board space. A unique modulation scheme and spread-spectrum switching allow filterless operation to create a compact, flexible, low-noise, efficient audio power amplifier. The MAX9715 features high 71dB at 1kHz PSRR, low 0.06% THD+N, industry-leading click-and-pop performance and a low-power shutdown mode.

The MAX9715 features an undervoltage lockout that prevents operation from an insufficient power supply and click-and-pop suppression that eliminates audible transients at startup and shutdown. The speaker amplifier includes thermal-overload and short-circuit protection.

The MAX9715 features unique, spread-spectrum operation that reduces the amplitude of spectral components at high frequencies, reducing EMI emissions that might otherwise be radiated by the speaker and cables. The switching frequency varies randomly by  $\pm 120\text{kHz}$  around the center frequency (1.22MHz). The modulation scheme is consistent with Maxim's Class D amplifiers but the period of the triangle waveform changes from cycle to cycle. Audio reproduction is not affected by the spread-spectrum switching scheme. Instead of a large amount of spectral energy present at multiples of the switching frequency that energy is now spread over a range of frequencies. The spreading is increased with frequency so that above a few megahertz, the wideband spectrum looks like white noise for EMI purposes (Figure 1).

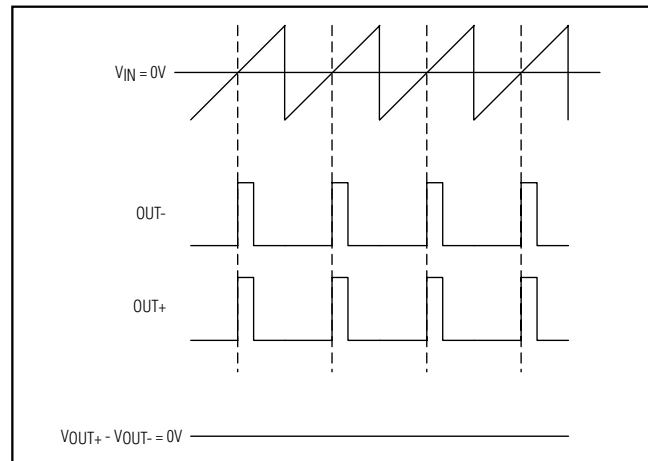


Figure 2. MAX9715 Output without Input Signal Applied

### Filterless Modulation/Common-Mode Idle

The spread-spectrum modulation scheme eliminates the LC filter required by traditional Class D amplifiers, improving efficiency, reducing component count, conserving board space and system cost. Conventional Class D amplifiers output a 50% duty cycle square wave when no signal is present. With no filter, the output square wave appears across the load, resulting in finite load current, which increases power consumption. When no signal is present at the input, the MAX9715 outputs switch as shown in Figure 2. The two outputs cancel each other because the MAX9715 drives the speaker differently, minimizing power consumption as there is no net idle-mode voltage across the speaker.

# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

### Efficiency

Efficiency of a Class D amplifier is attributed to the region of operation of the output-stage transistors. In a Class D amplifier, the output transistors act as current-steering switches and consume negligible additional power. Any power loss associated with the Class D output stage is mostly due to the  $I^2R$  loss of the MOSFET on-resistance, switching losses, and quiescent current overhead.

The theoretical best efficiency of a linear amplifier is 78%, however, that efficiency is only exhibited at peak output powers. Under normal operating levels (typical music or voice reproduction levels), efficiency falls below 30%. Under the same conditions, the MAX9715 still exhibits >80% efficiencies (Figure 3).

### Gain Selection

Drive GAIN high to set the gain of the speaker amplifiers to +9dB, drive GAIN low to set the gain of the speaker amplifiers to +10.5dB (see Table 1). The gain of the MAX9715 is calculated by the following equation:

$$20 \times \log\left(\frac{V_{OUT+} - V_{OUT-}}{V_{IN}}\right)$$

Table 2 shows the speaker amplifier input voltage needed to attain maximum output power from a given gain setting and load.

### Shutdown

The MAX9715 features a 0.1µA low-power shutdown mode that reduces quiescent current consumption and extends battery life. Driving  $\overline{SHDN}$  low disables the output amplifiers, bias circuitry, and drives BIAS to GND. Connect  $\overline{SHDN}$  to logic 1 for normal operation.

### Click-and-Pop Suppression

The MAX9715 speaker amplifiers feature Maxim's comprehensive, industry-leading click-and-pop suppression that eliminates any audible transients at startup. The outputs are high-impedance while in shutdown. During startup or power-up, the modulator bias voltage is set to the correct level while the input amplifiers are muted. The input amplifiers are muted for 25ms allowing the input capacitors to charge to the bias voltage ( $V_{BIAS}$ ). The amplifiers are then unmuted, ensuring click-free startup.

## Applications Information

### Filterless Operation

Traditional Class D amplifiers require an output filter to recover the audio signal from the amplifier's PWM output. The filters add cost, increase the solution size of the

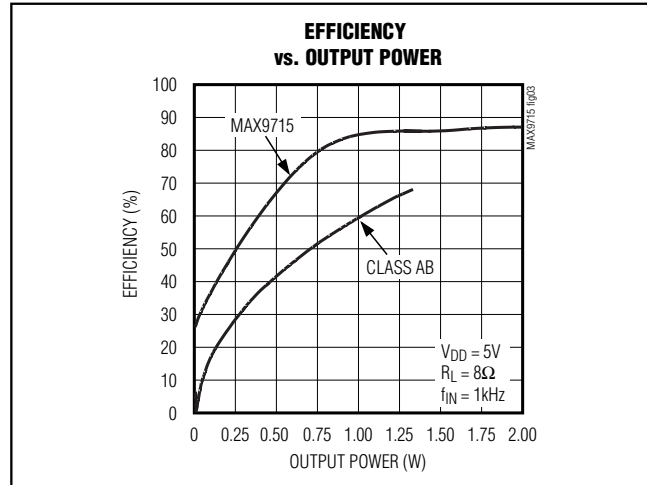


Figure 3. MAX9715 Class D Efficiency vs. Typical Class AB Efficiency

Table 1. MAX9715 Maximum Gain Settings

| GAIN | SPEAKER MODE GAIN (dB) |
|------|------------------------|
| 0    | +10.5                  |
| 1    | +9.0                   |

Table 2. MAX9715 Input Voltage and Gain Settings for Maximum Output Power

| GAIN (dB) | INPUT (VRMS) | RL (Ω) | POUT (W) |
|-----------|--------------|--------|----------|
| 10.5      | 0.90         | 4      | 2.3      |
| 9.0       | 1.08         | 4      | 2.3      |
| 10.5      | 1.00         | 8      | 1.4      |
| 9.0       | 1.19         | 8      | 1.4      |

amplifier, and can decrease efficiency. The traditional PWM scheme uses large differential output swings ( $2 \times V_{DD(P-P)}$ ), which causes large ripple currents. Any parasitic resistance in the filter components results in a loss of power, lowering the efficiency.

The MAX9715 does not require an output filter. The device relies on the inherent inductance of the speaker coil and the natural filtering of both the speaker and the human ear to recover the audio component of the square-wave output. The elimination of the output filter results in a smaller, less costly, more efficient solution.



## 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

Voice coil movement due to the square-wave frequency is very small because the switching frequency of the MAX9715 is well beyond the bandwidth of most speakers. Although this movement is small, a speaker not designed to handle the additional power may be damaged. Use a speaker with a series inductance > 30μH for optimum efficiency. Typical 8Ω speakers exhibit series inductances in the 30μH to 100μH range. The highest efficiency is achieved with speaker inductances > 60μH.

### Component Selection Input Filter

The input capacitor (C<sub>IN</sub>), in conjunction with the amplifier input resistance (R<sub>IN</sub>), forms a highpass filter that removes the DC bias from an incoming signal (see the *Typical Application Circuit*). The AC-coupling capacitor allows the amplifier to bias the signal to an optimum DC level. Assuming zero source impedance, the -3dB point of the highpass filter is given by:

$$f_{-3dB} = \frac{1}{2\pi \times R_{IN} \times C_{IN}}$$

R<sub>IN</sub> is the amplifier's internal input resistance value given in the *Electrical Characteristics* table. Choose C<sub>IN</sub> so f<sub>-3dB</sub> is well below the lowest frequency of interest. Setting f<sub>-3dB</sub> too high affects the amplifier's low-frequency response. Use capacitors with low-voltage coefficient dielectrics, such as tantalum or aluminum electrolytic. Capacitors with high-voltage coefficients, such as ceramics, may result in increased distortion at low frequencies.

The inability of small diaphragm speakers to reproduce low frequencies can be exploited to improve click-and-pop performance. Set the cutoff frequency of the MAX9715's input highpass filter to match the speaker's frequency response. Doing so will allow for smaller C<sub>IN</sub> values and reduce click-and-pop.

### Output Filter

The MAX9715 speaker amplifiers do not require output filters. However, output filtering can be used if a design is failing radiated emissions due to board layout, cable length, or the circuit is near EMI-sensitive devices. Use a ferrite bead filter or a common-mode choke when radiated frequencies above 10MHz are of concern. Use an LC filter when radiated frequencies below 10MHz are of concern, or when long cables (>75mm) connect the amplifier to the speaker. Figure 4 shows possible output filter connections.

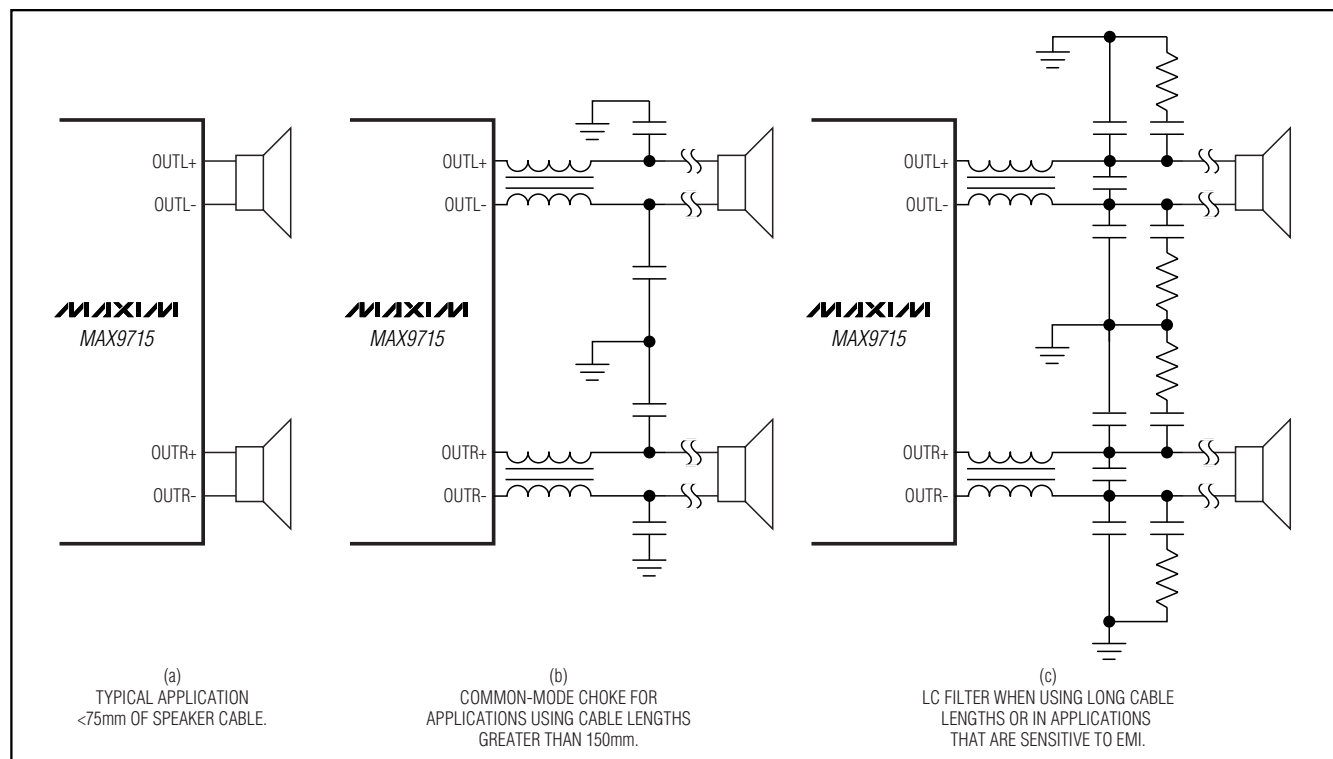


Figure 4. Optional Speaker Amplifier Output Filter—Guidelines for FCC Compliance

## 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

### Supply Bypassing, Layout, and Grounding

Proper layout and grounding are essential for optimum performance. Use large traces for the power-supply inputs and amplifier outputs to minimize losses due to parasitic trace resistance. Large traces also aid in moving heat away from the package. Proper grounding improves audio performance, minimizes crosstalk between channels, and prevents any switching noise from coupling into the audio signal. Route ground return paths that carry switching transients to power ground (PGND). Keep high-current return paths that connect to PGND short and route them away from analog ground (GND) and any traces or components in the audio input signal path. Use a star connection to connect GND and PGND together at one point on the PC board.

Bypass each  $PV_{DD}$  with a  $0.1\mu\text{F}$  capacitor to PGND. Bypass  $V_{DD}$  to GND with a  $0.1\mu\text{F}$  capacitor. Place a bulk capacitor between  $V_{DD}$  and PGND. Place the bypass capacitors as close to the MAX9715 as possible.

Use large, low-resistance output traces. Current drawn from the output increases as load impedance decreases. High-output-trace resistance decreases the power delivered to the load. For example, when compared to a  $0\Omega$  trace, a  $100\text{m}\Omega$  trace reduces the power delivered to a  $4\Omega$  load from 2.1W to 2.0W. Large output, supply, and GND traces decrease the thermal impedance of the circuit and allow more heat to be radiated from the MAX9715 to the air.

The MAX9715 thin QFN-EP package features an exposed thermal pad on its underside. This pad lowers the package's thermal impedance by providing a direct-

heat conduction path from the die to the PC board. Connect the exposed thermal pad to an electrically isolated pad of copper. A bigger pad area provides better thermal performance. Connect EP to GND if PC board layout rules do not allow for isolated pads of copper. If EP is connected to GND, ensure that high-current return paths do not flow through EP.

### Biamp Configuration

The *Typical Application Circuit* shows the MAX9715 configured as a mid-/high-frequency amplifier and the MAX9713 is configured as a mono bass amplifier. Capacitors C1 and C2 set the highpass cutoff frequency according to the following equation:

$$f = \frac{1}{2\pi \times R_{IN} \times C1}$$

where  $R_{IN}$  is the input resistance of the MAX9715 and  $C1 = C2$ . The  $10\mu\text{F}$  capacitors on the output of the MAX9715 ensure a two-pole roll-off with the  $5\Omega$  load shown.

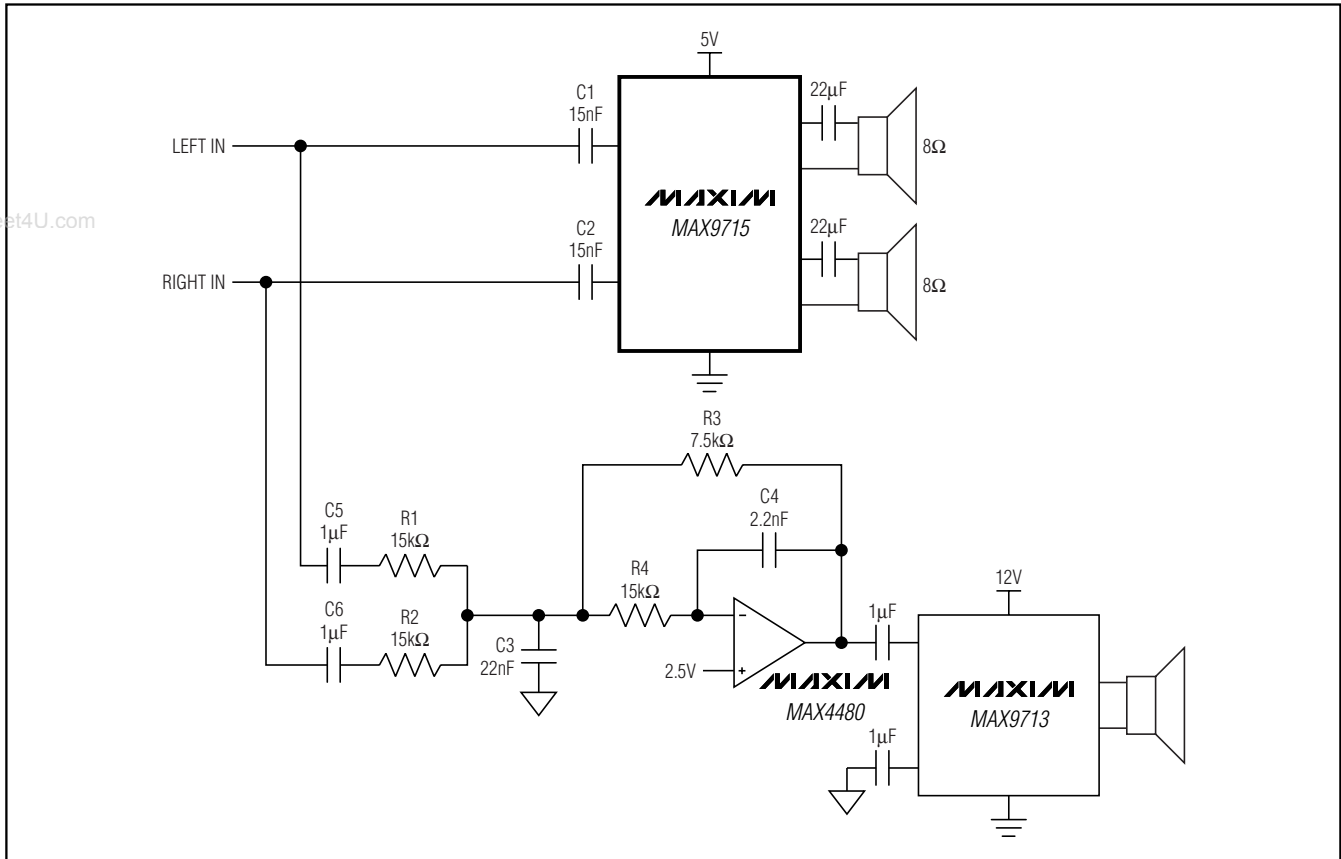
The stereo signal is summed to a mono signal and then sent to a two-pole lowpass filter. The filtered signal is then amplified by the MAX9713. The passband gain of the lowpass filter, for coherent left and right signals is  $(-2 \times R3) / R1$ , where  $R1 = R2$ . The cutoff frequency of the lowpass filter is set by the following equation:

$$f = \frac{1}{2\pi} \times \sqrt{\frac{1}{C3 \times C4 \times R3 \times R4}}$$

# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

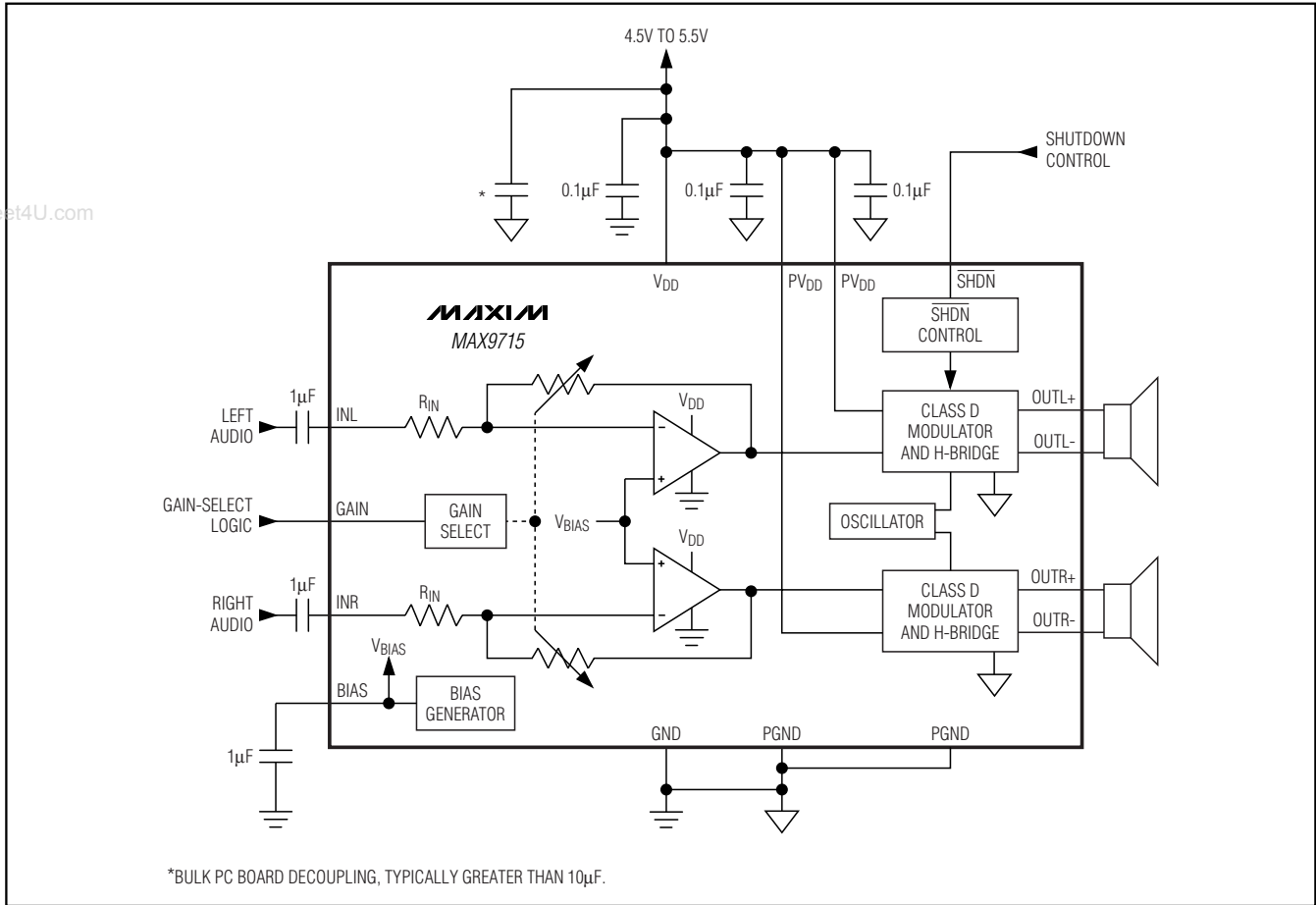
## Typical Application Circuit

MAX9715

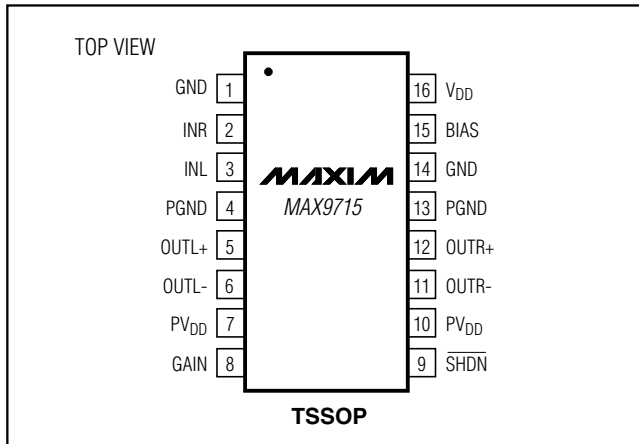


# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

## Typical Operating Circuit/Functional Diagram



### Pin Configurations (continued)



### Chip Information

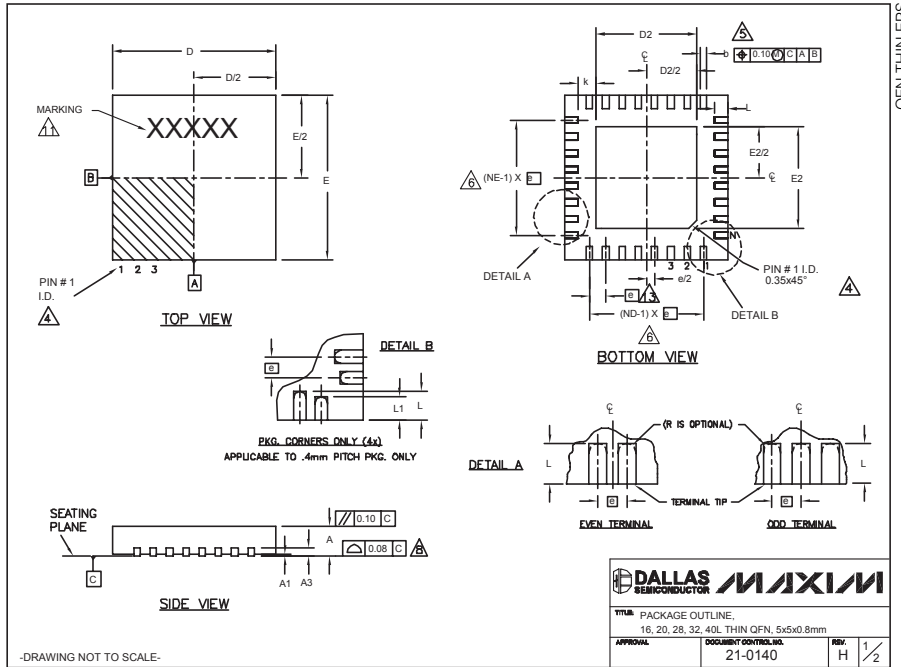
TRANSISTOR COUNT: 11,721  
 PROCESS: BICMOS

# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

MAX9715



**DALLAS SEMICONDUCTOR** **MAXIM**

TITLE: PACKAGE OUTLINE  
16, 20, 28, 32, 40L THIN QFN, 5x5x0.8mm

APPROVAL: DOCUMENT CONTROL NO. 21-0140 REV. H 1/2

| COMMON DIMENSIONS |           |      |      |           |      |      |           |      |      |           |      |      |           |      |      |
|-------------------|-----------|------|------|-----------|------|------|-----------|------|------|-----------|------|------|-----------|------|------|
| PKG. SYMBOL       | 16L 5x5   |      |      | 20L 5x5   |      |      | 28L 5x5   |      |      | 32L 5x5   |      |      | 40L 5x5   |      |      |
|                   | MIN.      | NOM. | MAX. | MIN.      | NOM. | MAX. | MIN.      | NOM. | MAX. | MIN.      | NOM. | MAX. | MIN.      | NOM. | MAX. |
| A                 | 0.70      | 0.75 | 0.80 | 0.70      | 0.75 | 0.80 | 0.70      | 0.75 | 0.80 | 0.70      | 0.75 | 0.80 | 0.70      | 0.75 | 0.80 |
| A1                | 0         | 0.02 | 0.05 | 0         | 0.02 | 0.05 | 0         | 0.02 | 0.05 | 0         | 0.02 | 0.05 | 0         | 0.02 | 0.05 |
| A3                | 0.20 REF. |      |      | 0.20 REF. |      |      | 0.20 REF. |      |      | 0.20 REF. |      |      | 0.20 REF. |      |      |
| b                 | 0.25      | 0.30 | 0.35 | 0.25      | 0.30 | 0.35 | 0.20      | 0.25 | 0.30 | 0.20      | 0.25 | 0.30 | 0.15      | 0.20 | 0.25 |
| D                 | 4.90      | 5.00 | 5.10 | 4.90      | 5.00 | 5.10 | 4.90      | 5.00 | 5.10 | 4.90      | 5.00 | 5.10 | 4.90      | 5.00 | 5.10 |
| E                 | 4.90      | 5.00 | 5.10 | 4.90      | 5.00 | 5.10 | 4.90      | 5.00 | 5.10 | 4.90      | 5.00 | 5.10 | 4.90      | 5.00 | 5.10 |
| e                 | 0.80 BSC. |      |      | 0.65 BSC. |      |      | 0.50 BSC. |      |      | 0.50 BSC. |      |      | 0.40 BSC. |      |      |
| k                 | 0.25      | -    | -    | 0.25      | -    | -    | 0.25      | -    | -    | 0.25      | -    | -    | 0.25      | 0.35 | 0.45 |
| L                 | 0.30      | 0.40 | 0.50 | 0.45      | 0.55 | 0.65 | 0.45      | 0.55 | 0.65 | 0.30      | 0.40 | 0.50 | 0.40      | 0.50 | 0.60 |
| L1                | -         | -    | -    | -         | -    | -    | -         | -    | -    | -         | -    | -    | 0.30      | 0.40 | 0.50 |
| N                 | 16        |      |      | 20        |      |      | 28        |      |      | 32        |      |      | 40        |      |      |
| ND                | 4         |      |      | 5         |      |      | 7         |      |      | 8         |      |      | 10        |      |      |
| NE                | 4         |      |      | 5         |      |      | 7         |      |      | 8         |      |      | 10        |      |      |
| JEDEC             | WHHB      |      |      | WHHC      |      |      | WHHD-1    |      |      | WHHD-2    |      |      | -----     |      |      |

| EXPOSED PAD VARIATIONS |      |      |      |      |      |      |      |                    |  |
|------------------------|------|------|------|------|------|------|------|--------------------|--|
| PKG. CODES             | D2   |      |      | E2   |      |      | L    | DOWN BONDS ALLOWED |  |
|                        | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |      |                    |  |
| T1655-1                | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | NO                 |  |
| T1655-2                | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | YES                |  |
| T1655N-1               | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | NO                 |  |
| T2055-2                | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | NO                 |  |
| T2055-3                | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | YES                |  |
| T2055-4                | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | NO                 |  |
| T2055-5                | 3.15 | 3.25 | 3.35 | 3.15 | 3.25 | 3.35 | 0.40 | YES                |  |
| T2855-1                | 3.15 | 3.25 | 3.35 | 3.15 | 3.25 | 3.35 | **   | NO                 |  |
| T2855-2                | 2.60 | 2.70 | 2.80 | 2.60 | 2.70 | 2.80 | **   | NO                 |  |
| T2855-3                | 3.15 | 3.25 | 3.35 | 3.15 | 3.25 | 3.35 | **   | YES                |  |
| T2855-4                | 2.60 | 2.70 | 2.80 | 2.60 | 2.70 | 2.80 | **   | YES                |  |
| T2855-5                | 2.60 | 2.70 | 2.80 | 2.60 | 2.70 | 2.80 | **   | NO                 |  |
| T2855-6                | 3.15 | 3.25 | 3.35 | 3.15 | 3.25 | 3.35 | **   | NO                 |  |
| T2855-7                | 2.60 | 2.70 | 2.80 | 2.60 | 2.70 | 2.80 | **   | YES                |  |
| T2855-8                | 3.15 | 3.25 | 3.35 | 3.15 | 3.25 | 3.35 | 0.40 | YES                |  |
| T2855N-1               | 3.15 | 3.25 | 3.35 | 3.15 | 3.25 | 3.35 | **   | NO                 |  |
| T3255-2                | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | NO                 |  |
| T3255-3                | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | YES                |  |
| T3255-4                | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | NO                 |  |
| T3255N-1               | 3.00 | 3.10 | 3.20 | 3.00 | 3.10 | 3.20 | **   | NO                 |  |
| T4055-1                | 3.20 | 3.30 | 3.40 | 3.20 | 3.30 | 3.40 | **   | YES                |  |

\*\* SEE COMMON DIMENSIONS TABLE

**DALLAS SEMICONDUCTOR** **MAXIM**

TITLE: PACKAGE OUTLINE  
16, 20, 28, 32, 40L THIN QFN, 5x5x0.8mm

APPROVAL: DOCUMENT CONTROL NO. 21-0140 REV. H 2/2

DRAWING NOT TO SCALE.

- NOTES:
- DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
  - ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
  - N IS THE TOTAL NUMBER OF TERMINALS.
  - THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JEDEC 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
  - DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.
  - ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
  - DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
  - COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
  - DRAWING CONFORMS TO JEDEC MO220, EXCEPT EXPOSED PAD DIMENSION FOR T2855-1, T2855-3, AND T2855-6.
  - WARPAGE SHALL NOT EXCEED 0.10 mm.
  - MARKING IS FOR PACKAGE ORIENTATION REFERENCE ONLY.
  - NUMBER OF LEADS SHOWN ARE FOR REFERENCE ONLY.
  - LEAD CENTERLINES TO BE AT TRUE POSITION AS DEFINED BY BASIC DIMENSION "e", ±0.05.

# 2.8W, Low-EMI, Stereo, Filterless Class D Audio Amplifier

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

| Symbol         | COMMON DIMENSIONS |      |                |      |
|----------------|-------------------|------|----------------|------|
|                | MILLIMETERS       |      | INCHES         |      |
|                | MIN.              | MAX. | MIN.           | MAX. |
| A              | —                 | 1.10 | —              | .043 |
| A <sub>1</sub> | 0.05              | 0.15 | .002           | .006 |
| A <sub>e</sub> | 0.85              | 0.95 | .033           | .037 |
| b              | 0.19              | 0.30 | .007           | .012 |
| b <sub>1</sub> | 0.19              | 0.25 | .007           | .010 |
| c              | 0.09              | 0.20 | .004           | .008 |
| c <sub>1</sub> | 0.09              | 0.14 | .004           | .006 |
| D              | SEE VARIATIONS    |      | SEE VARIATIONS |      |
| E              | 4.30              | 4.50 | .169           | .177 |
| e              | 0.65 BSC          |      | .026 BSC       |      |
| H              | 6.25              | 6.55 | .246           | .258 |
| L              | 0.50              | 0.70 | .020           | .028 |
| N              | SEE VARIATIONS    |      | SEE VARIATIONS |      |
| α              | 0°                | 8°   | 0°             | 8°   |

| JEDEC | N  | VARIATIONS  |      |        |      |      |
|-------|----|-------------|------|--------|------|------|
|       |    | MILLIMETERS |      | INCHES |      |      |
|       |    | MIN.        | MAX. | MIN.   | MAX. |      |
| AB-1  | 14 | D           | 4.90 | 5.10   | .193 | .201 |
| AB    | 16 | D           | 4.90 | 5.10   | .193 | .201 |
| AC    | 20 | D           | 6.40 | 6.60   | .252 | .260 |
| AD    | 24 | D           | 7.70 | 7.90   | .303 | .311 |
| AE    | 28 | D           | 9.60 | 9.80   | .378 | .386 |

**NOTES:**  
 1. DIMENSIONS D AND E DO NOT INCLUDE FLASH  
 2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm PER SIDE  
 3. CONTROLLING DIMENSION: MILLIMETER  
 4. MEETS JEDEC OUTLINE MO-153. SEE JEDEC VARIATIONS TABLE  
 5. 'N' REFERS TO NUMBER OF LEADS  
 6. THE LEAD TIPS MUST LIE WITHIN A SPECIFIED ZONE. THIS TOLERANCE ZONE IS DEFINED BY TWO PARALLEL PLANES. ONE PLANE IS THE SEATING PLANE, DATUM [-C-]; THE OTHER PLANE IS AT THE SPECIFIED DISTANCE FROM [-C-] IN THE DIRECTION INDICATED

-DRAWING NOT TO SCALE-

TSSOP4.40mm.EPS

**DALLAS SEMICONDUCTOR** **MAXIM**

TITLE: PACKAGE OUTLINE, TSSOP 4.40mm BODY

|          |                                 |           |     |
|----------|---------------------------------|-----------|-----|
| APPROVAL | DOCUMENT CONTROL NO.<br>21-0066 | REV.<br>G | 1/1 |
|----------|---------------------------------|-----------|-----|

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